

Effects of Granulosis Virus on Red-Banded Leaf Roller Pupal and Adult Populations^{1, 2}

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RECEIVED FOR PUBLICATION APRIL 13, 1970

Abstract: Observations were made on several populations of red-banded leaf rollers exposed to high levels of granulosis virus within forty-eight hours after the larvae had hatched. Not only is the adult population decreased in size, but the sex ratios are different from those found in healthy pupal and adult populations.

In general, progressive viral infections of Lepidoptera exist only in larvae and pupae. It is of interest, especially to those investigating the virus as a biological control agent, to observe how such infections contracted in early larval instars may influence subsequent population dynamics.

Tanada and Tanabe (1964) worked with the armyworm (*Pseudaletia unipuncta*, Haworth) and a cytoplasmic polyhedral virus. Mean values of the fecundity and of the life spans of adult armyworms reared from larvae exposed to cytoplasmic polyhedral virus did not differ from larvae unexposed to the virus. The lowest number of eggs laid occurred in matings in which at least one member had been exposed to the virus. However, there were indications in two or three experiments that the infected adults had shorter life spans than uninfected adults. Adult males outlived the females for both the adults from virus-treated larvae and from control larvae.

A considerable decrease of adult life span was also found by Martignoni (1964). In this case a progressive nuclear polyhedral virus infection was experimentally induced in an adult noctuid moth, *Peridroma saucia* (Hübner).

The present study with the red-banded leaf roller *Argyrotaenia velutinana* (Walker) and the granulosis virus *Bergoldia clistorhabdion* demonstrates the effects of a heavy infection, induced in first instar larvae, on the size and sex ratio of the subsequent adult population. Further evidence of disturbances caused by the pathogen in fecundity and the hatching rates of eggs from infected female adults will be presented elsewhere.

MATERIALS AND METHODS

Throughout these studies the red-banded leaf roller colony was reared continually on an artificial medium (E-5) under laboratory conditions as described by Karpel and Hagmann (1968).

¹ This study was connected with Project no. 12-14-100-8296(33), sponsored by the USDA, Beltsville, Maryland. This paper is part of a thesis submitted by the senior author to the Graduate School of Rutgers University in partial fulfillment of the requirements of the Ph.D. degree in Entomology.

² Paper of the Journal Series, New Jersey Agricultural Experiment Station, Rutgers—The State University, New Brunswick, New Jersey 08903.

TABLE 1. Composite of Seven Healthy Populations.

Number of Days After Hatching When Pupae Were Collected	Number of Pupae Collected and Percentage Emerging as Adults	
	Male	Female
24	172 (93%)*	50 (92%)*
25	114 (92%)	58 (88%)
26	126 (95%)	85 (93%)
27	148 (97%)	117 (91%)
28	135 (93%)	121 (94%)
29	126 (92%)	99 (97%)
30	96 (94%)	99 (95%)
31	71 (96%)	109 (98%)
32	61 (100%)	83 (89%)
33	60 (90%)	81 (91%)
34	40 (90%)	50 (96%)
35	23 (91%)	49 (90%)
36	15 (73%)	55 (98%)
37	22 (86%)	31 (94%)
38	15 (80%)	44 (89%)
39	12 (75%)	33 (88%)
40+	9 (78%)	21 (90%)

Overall percent emergence of males: 93.01%

Overall percent emergence of females: 93.16%

Overall percent emergence of total population: 93.08%

Male/female ratio of pupae: 1.05

Male/female ratio of adults: 1.05

* Number of pupae collected on the 24th day includes those which pupated on the 19th through the 24th days, inclusive.

To aid in understanding how an adult population is affected by infection with the granulosis virus during the larval stage, the rates of pupation and subsequent emergence of adults were studied. Three populations (#69, 70 and 87) were infected in the larval stage by spraying the food medium and larvae in the larval rearing boxes with 0.5 mls of a 1×10^8 granules per milliliter concentration of virus within forty-eight hours of the time the larvae hatched.

Seven healthy populations were also used for a composite profile on the normal developmental rates of the healthy insect. From the beginning to the end of the pupation period pupae were removed daily from the larval rearing boxes, counted, washed in 1% sorbic acid in 70% ethanol, and placed in plastic petri dishes. Pupae from populations #69 and 70 were pooled, while pupae from populations #87 and the control populations were separated by sex. As male and female moths eclosed, the dates when they pupated were recorded, and they were removed from their respective petri dishes. In this manner

TABLE 2. Populations #69 and #70, Infected the Day after Hatching.

Number of Days After Hatching When Pupae Were Collected	Number of Pupae Collected and Percentage Emerging as Adults (Composite of Male and Female)
21	16 (100%)
22	7 (85%)
23	20 (80%)
24	13 (92%)
25	36 (60%)
26	32 (44%)
27	15 (33%)
28	15 (35%)
29	12 (17%)
30	5 (60%)
31	5 (40%)
32	8 (25%)
33	4 (50%)

Overall percent emergence: 59.04%

relative rates of male and female pupation and emergence, as well as the actual number of insects involved, were obtained.

RESULTS AND DISCUSSION

Seven healthy populations were studied and the results pooled to obtain the data listed in Table 1. It is observed that the peak rate of male pupation occurs on approximately the twenty-seventh day after hatching while female pupation reaches its peak approximately a day later and does not fall off as rapidly as does male pupation. Male and female pupal periods were generally of equal duration. However, male moths were usually obtained at least a day earlier than female moths as male larvae pupated earlier than female larvae.

Both males and females have a high rate of emergence as adults with 93.01% of males emerging and 93.16% of females emerging. Thus, 93.08% of all healthy pupae studied successfully emerged as adult moths. While the emergence rates of males pupating late (after 35 days of larval life) decreased significantly, emergence rates for females pupating late did not drop to a comparable degree.

The sex ratio in the healthy populations remained constant throughout pupation and emergence with the male-to-female ratio of pupae being 1.05, and male-to-female ratio of adults also being 1.05.

The two populations, #69 and 70, infected the day after hatching, show that the emergence rates were greatly affected by the presence of the pathogen (Table 2). Emergence fell to an average of 59.04%. It was also observed that larvae which pupated early had a higher emergence rate than did those which pupated later. Those insects pupating on the twenty-sixth day after

TABLE 3. Population #87, Infected the Day of Hatching.

Number of Days After Hatching When Pupae were Collected	Number of Pupae Collected and Percentage Emerging as Adults	
	Male	Female
21	4 (100%)	1 (100%)
22	9 (98%)	2 (100%)
23	22 (91%)	3 (100%)
24	33 (40%)	8 (75%)
25	43 (90%)	13 (100%)
26	36 (67%)	14 (93%)
27	38 (82%)	32 (100%)
28	25 (44%)	12 (100%)
29	25 (44%)	29 (97%)
30	18 (44%)	16 (100%)
31	7 (71%)	10 (90%)
32	12 (25%)	7 (100%)
33	13 (39%)	13 (95%)
34	5 (60%)	4 (100%)
35	5 (20%)	5 (80%)
36	11 (55%)	4 (100%)
37	5 (40%)	3 (100%)
38	6 (50%)	3 (100%)
39	6 (50%)	4 (75%)
40-	11 (45%)	6 (100%)

Overall percent emergence of males: 61.38%

Overall percent emergence of females: 95.24%

Overall percent emergence of total population: 73.61%

Male/female ratio of pupae: 1.77

Male/female ratio of adults: 1.14

hatching had an emergence rate of 44% as compared with larvae pupating on the twenty-first day after hatching with an emergence rate of 100%.

Population #87, infected on the day of hatching, showed differences in mortality rates between the sexes (Table 3). A significant decrease in overall emergence is seen, with 73.61% emergence as compared with 93.08% emergence in the healthy populations. Pupation of infected females reached their peak as in the healthy populations, on the twenty-seventh day after hatching, and males preceded the females by a day or two. However, unlike the healthy males, only 61.38% of the infected male pupae emerged as adults. The female pupae, conversely, had an emergence rate comparable to that of the healthy population (95.24%).

Although infected males had a low emergence rate, they formed a higher ratio of the adult population than did healthy males. Where the healthy population ratio of male-to-female pupae was 1.05, in the infected population the

ratio of male-to-female pupae was 1.77. This ratio fell significantly to 0.14 in the adult population. Thus, the sex ratio stability seen in the healthy population was not observed in the infected population.

As in populations #69 and 70, emergence rates for males pupating later than normal tended to decrease. Females maintained a high emergence throughout the entire period.

SUMMARY AND CONCLUSIONS

Observations were made on the rates of pupation and subsequent emergence of several populations of red-banded leaf rollers that had been exposed to high levels of granulosis virus within forty-eight hours after the larvae had hatched. Not only is the adult population decreased in size by infection with the virus, but the sex ratios are also different from those found in normal healthy pupal and adult populations. While the male/female ratio of pupae was 1.05 and of adults was 1.05 in healthy populations, the male/female ratio of pupae was 1.77 and of adults was 1.14 in infected populations.

From the above it is clear that pupation and emergence rates for larvae exposed to high levels of granulosis virus do differ from those seen in normal healthy populations. It is also apparent that males and females are affected differently by the presence of the virus. Males appear to be able to tolerate the virus for a longer period of time than do females, as males succumb in larger numbers as pupae than as larvae. Females appear most susceptible during the larval period, probably because of earlier mobilization of the fat body. The selection pressure of the virus on the red-banded leaf roller population is more severe for the female than for the male.

Literature Cited

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